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Remarks of
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CONFERENCE ON MAGNETISM & MAGNETIC MATERIALS
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"The U. S. Space Program -- An Appraisal"

Mr. Chairman, Gentlemen -- Those persons responsible for the planning and staging of this conference are to be congratulated on the high quality of the program that is being presented. It is becoming increasingly clear that much progress toward the goal of international understanding and good will results from meetings such as this one, where scientists and engineers from many countries discuss their common problems and exchange information on the results of their researches on a frank and open basis. I am happy that I am associated with an agency of the United States Government which has as one of its principal objectives cooperation with other nations and groups of nations in work done pursuant to the Act which governs its activities.

The National Aeronautics and Space Administration has a significant interest in research on magnetic materials and in developing a better understanding of magnetic phenomena here on earth, in space and in the vicinity of the other planets of our solar system. But it would be presumptuous of me, an ordinary administrator, to lecture to this distinguished group of experts in the field on the subject of magnetism and magnetic materials. Instead, I propose to tell you briefly about the dimensions and principal areas of effort of the program we are pursuing in space research. Naturally, I will identify the nature of our interest in the specialty with which you are concerned. Finally, I want to attempt an assessment of the United States program in space exploration with perhaps a sidelong glance at the comparable efforts of our principal competitor in this field -- the Soviet Union. In the preparation of this paper, I have had the assistance of several very able scientists who are members of our staff at NASA.

Let me first dispose of the elements of our program that undergird our scientific and exploratory efforts -- the matter of launch vehicles and tracking and data acquisition stations. In all of this discussion, I hope you will keep in mind the fact that the so-called "Space Age" as heralded by the successful launching by the Soviet Union of Sputnik I is only three years old. NASA itself has been in business only 2 years and 2 months. Very early in the game, we recognized the serious handicap we faced in the matter of launch vehicle thrust capability. As a result, we set in motion, in many instances with the cooperation of the Department of Defense, a development program intended to correct this deficiency. The intent was and is to provide a family of reliable launch vehicles of varying spacecraft or payload lifting capabilities. Today we are using ten or more different combinations of rockets to launch spacecraft in the NASA and Defense Department space programs. We expect to reduce this number to five within the next few years.

The resulting launch vehicle systems will range from the Scout, a solid propellant rocket combination which will put a 150 pound spacecraft into a 300 mile orbit to the Saturn class of vehicles which, in its three and four stage configurations, will place in the same nominal orbit spacecraft ranging from 19,000 to 45,000 pounds. Engine and component developments are underway for both conventional and nuclear powered systems which will permit the design and construction of even more powerful launch vehicle systems in the latter part of the decade of the 60's. In the third quarter of 1961, we should begin the test flights of the Atlas-Centaur vehicle, a hydrogen-oxygen system which should enable us to place an 8500 pound spacecraft in that same 300 mile orbit. In the course of the next 12 months, Thor and Atlas-based Agena B vehicles will begin to be used in our program with lifting capabilities in the 1600 to 5000 pound class. These developments take time -- and effort -- but we can now speak with confidence about their availability in the relatively immediate future.

Space experiments are useless if we are not able to acquire information from them about the environment of outer space. Thus tracking and data acquisition stations have been installed and are now operating in 14 countries around the world. Tracking facilities are under construction in 7 additional countries. Stations outside the territorial limits of the United States are being operated in whole or in part by nationals of the host country thus giving substance to our desires to encourage international participation in our space exploration program.

Turning now to the matter of experiments planned for the next several years, our schedules call for 24 to 30 major launches per year. In the space sciences area, perhaps the best way to give you an impression of the nature of the program is to list the short titles assigned to these experiments. We are working in the following areas of space science: atmospheres, ionospheres, gravitational and magnetic fields, radiations and astronomy. I have indicated most of these areas in the plural to denote the fact that we are concerned not only with measurements in the vicinity of the earth, but also near the moon, the planets and even the sun. Most of these areas will involve many flights spaced over a considerable number of years.

A program of unmanned lunar and planetary exploration is proceeding under the vigorous direction of our Jet Propulsion Laboratory operated under contract to NASA by the California Institute of Technology. The first launching in this program should take place in the latter half of

1961 and launchings will continue through the decade. The search for extraterrestrial life forms will be included in the experiments to be flown in this program as soon as we have completed initial experiments assuring us of reliability in spacecraft performance.

Encouraging results in initial experiments in the application of satellite techniques to communications and meteorology point the way toward intensified efforts to bring about the establishment of satellite-based operational systems in these fields. In the commercial communications area, we expect enthusiastic cooperation from industrial organizations active in the various facets of the communications industry. In meteorology, we are working closely with the Weather Bureau and the Weather Services of the military departments in structuring a development program that should lead to useful results in the next few years. Thus we hope to fulfill, at least in part, the basic objective of the United States space exploration effort -- "that activities in space should be devoted to peaceful purposes for the benefit of all mankind."

Finally, our program includes a determined attempt to understand the capability of man to perform useful tasks in space. The first element in the manned space flight area -- Project Mercury -- is nearing the crucial phase of manned ballistic flight. Early in 1961, one of the seven astronauts will be lofted about 125 miles above the surface of the earth and will land some 200 miles down range. He will be in flight approximately 16 minutes and will experience 5 minutes of weightlessness during which we hope to learn something of his physiological and psychological reaction to this first approach to flight through space. Later in the year, barring unforeseen difficulties, orbital manned flight will be attempted.

All of this activity is engaging the determined efforts of some 19,000 NASA people and countless thousands in industry throughout the country. In our Mercury program we are being supported, particularly in the recovery manuever, by elements of the Department of Defense. In the NASA program alone, 915 millions of dollars will be committed during the course of the current fiscal year. Truly, a massive assault on this complex, difficult and exciting field of research and development is being carried out in consonance with our stated mission of exploring space for beneficial purposes for all mankind.

The subject of this conference is relevant and important to all of our space programs. The relevance appears in many forms -- from the constant need for magnetic devices in instrumentation to the desire to understand the magnetic fields of our galaxy. The role of magnetism in the space effort can be illustrated best by using examples of a divergent nature.

First, the demand for improved instrumentation will continue. Advances in magnetic materials which lead to more efficient and reliable transformers, relays, inductors, storage cores, tapes, etc., are important contributions to the space effort. The demand is not, however, limited to improvements. Our objectives in space create a need for new instruments based on the development of new techniques. Many of these have and will come from research on the magnetic properties of matter. Just as research on ferrites opened new avenues in microwave communications and data systems, we anticipate in our activites new boulevards and side streets in the future.

An illustrative link between the magnetic properties of matter and the study of magnetic fields in space occurs in the design of magnetometers for space exploration. Development of the proton precessional magnetometer carried in Vanguard III was made possible by research on nuclear magnetism. Its operation depended on the magnetization of protons in gasoline. (Water could have been used equally well. Twenty years ago a man stating that he could measure magnetic field with water or gasoline would have been declared a crackpot -- and, if he claimed further that he could do this 2000 miles above the earth by pressing a button he would have been put in an institution.) A more recent development for space exploration is the "optical pumping" magnetometer which measures a magnetic field by measuring (in the form of frequency) the magnetic splitting of an electron energy level in rubidium vapor. As energy differences a factor of 10^{14} smaller than the energy of visible light are precisely determined, the instrument is essentially an ultra-sensitive spectograph in which a frequency counter rather than a photographic plate is used for display.

These instruments and others are used to increase our knowledge of magnetic fields in space. The knowledge is needed not only for explanations of geophysical and solar phenomena but also for understanding our space environment. When we pass from the lower atmosphere to altitudes of 1000 miles and beyond, we are moving from a region where our atmosphere is under hydrostatic and hydrodynamic conditions to a region where the magnetic field and hydromagnetics become the controlling features. The discovery of the radiation belts and the results of the Argus experiments dramatically illustrated this and with subsequent experiments we are increasingly aware of our magnetic field environment and the complexity of plasma and field interactions.

Magnetic fields in space can also present environmental problems in novel ways. The spin of a satellite with large conducting areas is rapidly damped by motional induction. The earth's field will also exert a torque on a satellite possessing a significant magnetic moment from magnetic parts or current loops. These factors can, however, be used to advantage with proper design. It was discovered that magnetic torques on Tiros I, for example, maintained the proper orientation of the satellite for an extended time and, thus, additional pictures were obtained.

Let me now attempt a characterization of the main thrust of our U.S. space exploration program and an assessment of the values inherent in it as we look to the future. Basically, we adhere to the belief that a broad program of fundamental investigations of the various phenomena to be found in space and on and immediately surrounding the moon and the planets will lead to a better understanding of the physical world of which we are a part. To accomplish this purpose we have enlisted the advice and participation of the National Academy of Sciences through the medium of their Space Science Board, of individual scientists and engineers associated with colleges and universities and other non-profit institutions and of industrial and research organizations the country over. Naturally, our own people have made many and valuable contributions to the planning of the programs we have underway and in prospect.

In this effort, we have been fortunate in the sense that the U.S. has developed in the past two decades a tradition of strong support for research, a truly powerful base for scientific operations including many large laboratories and research centers with highly trained staffs. Because of these resources, the nation has been able to develop, in a comparatively short span of time, a vigorous program in the space sciences without reducing the level of effort in other fields of research. We have, in fact, developed an entirely new field to a very high level of activity in the short space of little more than two years.

It is a fact that the test tubes we must use in these programs are expensive. They require the ingenuity and diligent efforts of a large number of well trained and experienced people in industry and elsewhere whose contributions in the fields of vehicle design, propulsion, guidance and control, instrumentation and data retrieval and analysis have been outstanding. Much of the technology undergirding this activity has been developed in support of military research and development programs over the past several years, of course. But the main point I would make is that we have adhered to the belief that we will attain our objectives of acquiring new knowledge and of applying that knowledge for useful purposes most effectively through the maintaining of diversity and depth in our approach to the exploration of space.

From this program has come a variety of important results. The U.S. has been responsible for:

- the first detection of trapped particles through the discovery and identification of the Van Allen belts

- satellite contributions to geodesy and celestial mechanics; the pear-shaped earth; gravitational perturbations by the sun and moon; the effect of solar radiation pressure

- a correlation between solar activity and atmospheric density through satellite drag measurements

- a correlation between ground-based radiation, field and atmospheric data and data received simultaneously from Pioneer V in deep space and from Explorer VII near the earth

- Tiros cloud cover photographs which must certainly lead to significant advances in the field of weather forecasting as additional experimentation is undertaken

-NASA's Echo passive and the Army's Courier active-repeater communications experiments which are charting the path to the satellite-based communications systems of the future

-the Navy's Transit satellite experiments which promise all-weather navigation capabilities for both military and non-military ships and aircraft.

The ultimate goal of enabling man to travel through space wherever and whenever he chooses will be realized only when we have developed a much more complete understanding of the space environment. Thus far we have only scratched the surface, significant though our findings to date have been.

Important as the spectacular results of our Soviet sompetitors have been, I am convinced that the more fundamental and apparently more broadly-based program we are pursuing must, in the end, lead to the more useful results for mankind. As launch vehicle systems of greater thrust become available to us, we will be able to utilize the knowledge we have gained to assert our leadership in whatever field of space exploitation we desire as a nation to undertake.

Finally, in making an assessment of our position with respect to that of the Soviet Union it is important to note that the average quality of Soviet scientific research is the same as our own. This opinion, held by highly qualified scientists on our staff, is based on a perusal of Soviet literature and on personal contacts in conferences held between 1956 and 1960, both in nuclear physics and in areas related to space research. The range of abilities of Soviet scientists would appear to approximate those of U.S. scientists. A few are brilliant, as good as our best physicists, and the majority do conventional but necessary research. But it is a striking fact that in spite of the equality of talent in U.S. and U.S.S.R. science, nearly all of the highly original work in space research has come out of the U.S. program.

While I am as aware as anyone can be of the deep impression made on the rest of the world by the spectacular nature of the Soviet successes in this field to date -- an impression that has been heightened by an enormous propaganda effort -- I hold very strongly the opinion that this competition will not be won by a few spectacular shots. I would remind you that our Echo communications satellite -- a comparatively inexpensive experiment -- has made a deep and more abiding impression in other nations than many of the more difficult, more expensive, and perhaps more scientifically significant experiments we have thus far carried out. We will have more such successes that will bring recognition to this nation as we pursue the program I have described tonight.

It is extremely important to note that this assessment refers to the situation at the present moment. The USSR is believed to be training scientists at a rate substantially greater than the rate of training in the United States. It is entirely possible that the Soviet Union may strengthen the weak spots in its scientific structure and move ahead to overtake us in every important area of research in the course of the next decade. Let me note again that the intrinsic ability of the Soviet scientific community is not inferior to our own. There is, therefore, no reason why they cannot overtake us in this period if we do not continue to develop and strengthen our own program. To accomplish this purpose must be one of our top objectives in the years ahead. I have faith that we can and will do this, if we have the good sense and the intestinal fortitude to put our minds to the task.

Thank you for your time and attention.

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